



HORIZON REPORT

2010 K-12 EDITION

The New Media Consortium

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The New Media Consortium

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To learn more about CoSN visit <http://www.cosn.org>.

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EXECUTIVE SUMMARY

The *Horizon Report* series is the most visible outcome of the New Media Consortium's Horizon Project, an ongoing research effort established in 2002 that identifies and describes emerging technologies likely to have a large impact on teaching, learning, research, or creative expression within education around the globe. This volume, the *2010 Horizon Report: K-12 Edition*, examines emerging technologies for their potential impact on and use in teaching, learning, and creative expression within the environment of pre-college education. The hope is that the report is useful to educators worldwide, and the international composition of the Advisory Board reflects the care with which a global perspective was assembled. While there are many local factors affecting the practice of education, there are also issues that transcend regional boundaries, questions we all face in K-12 education, and it was with these in mind that this report was created. The *2010 Horizon Report: K-12 Edition* is the second in the K-12 series of reports and is produced by the NMC in collaboration with the Consortium for School Networking (CoSN), with the generous support of HP.

Each edition of the *Horizon Report* introduces six emerging technologies or practices that are likely to enter mainstream use in the educational community within three adoption horizons over the next one to five years. Each report also presents critical trends and challenges that will affect teaching and learning over the same time frame. To identify these areas, the project has drawn on an ongoing conversation among knowledgeable persons in the fields of business, industry, and education; on published resources, current research, and practice; and on the expertise of both the NMC community and the communities of the members of the Horizon Project's K-12 Advisory Board, an international body of experts in education, technology, and other fields. The Advisory Board, chosen to broadly represent a range of perspectives in K-12 education, engaged in a discussion around a set of research questions

intended to surface significant trends and challenges and to identify a wide array of potential technologies for the report. Over the course of a few weeks, the Advisory Board came to a consensus about the six topics that will appear here. The examples and readings under each topic area are meant to provide practical models as well as access to more detailed information. Wherever possible, an effort was made to highlight the innovative work going on among elementary, middle, and high schools around the world. The precise research methodology employed in producing the report is detailed in a special section that follows the body of the report.

The report's format is consistent from year to year, opening with a discussion of the trends and challenges identified by the Advisory Board as most critical for the next five years. The format of the main section closely reflects the focus of the Horizon Project itself, centering on the applications of emerging technologies to education and creativity. Each topic is introduced with an overview that describes what it is, followed by a discussion of the particular relevance of the topic to teaching, learning, or creativity. Examples of how the technology is being, or could be applied to those activities are given. Finally, each section closes with an annotated list of suggested readings and additional examples that expand on the discussion in the report and a link to the tagged resources collected during the research process by project staff, the Advisory Board, and others in the growing Horizon Project community.

Key Trends

The technologies featured in each edition of the *Horizon Report* are embedded within a contemporary context that reflects the realities of the time, both in the sphere of education and in the world at large. To assure this perspective, each Advisory Board researches, identifies, and ranks key trends that are currently affecting the practice of teaching, learning, and creativity, and uses these as a lens for its later

work. These trends are surfaced through an extensive review of current articles, interviews, papers, and new research. Once identified, the list of trends is ranked according to how significant an impact they are likely to have on education in the next five years. The following five trends have been identified as key drivers of technology adoptions for the period 2010 through 2015; they are listed here in the order they were ranked by the Advisory Board.

- *Technology is increasingly a means for empowering students, a method for communication and socializing, and a ubiquitous, transparent part of their lives.* Technology is impacting all of our lives, and especially the lives of students, in new and expanding ways. Once seen as an isolating influence, technology is now recognized as a primary way to stay in touch and take control of one's own learning. Multisensory, ubiquitous, and interdisciplinary, technology is integrated into nearly everything we do. It gives students a public voice and a means to reach beyond the classroom for interaction and exploration.
- *Technology continues to profoundly affect the way we work, collaborate, communicate, and succeed.* Information technologies impact how people work, play, learn, socialize, and collaborate. Increasingly, technology skills are also critical to success in almost every arena, and those who are more facile with technology will advance while those without access or skills will not. The digital divide, once seen as a factor of wealth, is now seen as a factor of education: those who have the opportunity to learn technology skills are in a better position to obtain and make use of technology than those who do not. Evolving occupations, multiple careers, and an increasingly mobile workforce contribute to this trend.
- *The perceived value of innovation and creativity is increasing.* Innovation is valued at the highest levels of business and must be embraced in schools if students are to succeed beyond their

formal education. The ways we design learning experiences must reflect the growing importance of innovation and creativity as professional skills. Innovation and creativity must not be linked only to arts subjects, either; these skills are equally important in scientific inquiry, entrepreneurship, and other areas as well.

- *There is increasing interest in just-in-time, alternate, or non-formal avenues of education, such as online learning, mentoring, and independent study.* More and more, the notion of the school as the seat of educational practice is changing as learners avail themselves of learning opportunities from other sources. There is a tremendous opportunity for schools to work hand-in-hand with alternate sources, to examine traditional approaches, and to reevaluate the content and experiences they are able to offer.
- *The way we think of learning environments is changing.* Traditionally, a learning environment has been a physical space, but the idea of what constitutes a learning environment is changing. The “spaces” where students learn are becoming more community-driven, interdisciplinary, and supported by technologies that engage virtual communication and collaboration. This changing concept of the learning environment has clear implications for schools.

Critical Challenges

Along with current trends, the Advisory Board notes critical challenges that schools face, especially those that are likely to continue to affect education over the five-year time period covered by this report. Like the trends, these are drawn from a careful analysis of current events, papers, articles, and similar sources, as well as from the personal experience of the Advisory Board members in their roles as leaders in education and technology. Those challenges ranked as most significant in terms of their impact on teaching, learning, and creative inquiry in the coming years are listed here, in the order of importance assigned them by the Advisory Board.

- *Digital media literacy continues its rise in importance as a key skill in every discipline and profession.* The challenge is due to the fact that despite the widespread agreement on its importance, training in digital literacy skills and techniques is rare in teacher education and school district professional development programs. As teachers begin to realize that they are limiting their students by not helping them to develop and use digital media literacy skills across the curriculum, the lack of formal training is being offset through professional development or informal learning, but we are far from seeing digital media literacy as a norm. This challenge is exacerbated by the fact that digital literacy is less about tools and more about thinking, and thus skills and standards based on tools and platforms have proven to be somewhat ephemeral.
- *Students are different, but educational practice and the materials that support it are changing only slowly.* Schools are still using materials developed to teach the students of decades ago, but today's students are actually very different in the way they think and work. Schools need to adapt to current student needs and identify new learning models that are engaging to younger generations. Many education professionals feel that a shift to a more learner-centered model focused on the development of individual potential instead of the imposition of a body of knowledge would lead to deeper and more sustained learning across the curriculum. To support such a change, both teaching practice and the tools used in the classroom must adapt. Assessment has also not kept pace with new modes of working, and must change along with teaching methods, tools, and materials.
- *Many policy makers and educators believe that deep reform is needed, but at the same time, there is little agreement as to what a new model of education might look like.* It is difficult to envision profound change in a system as firmly established as K-12 education is today.

Proponents of change promote more learner-centered approaches; open content; programs for continuing teacher professional development in partnership with higher education institutions; and the use of social networking tools to increase access to peers and professionals for both teachers and students, but not everyone is in agreement. Opinions also differ on how to make (and measure) progress at all and whether it is better to build success slowly, using pilots and small proof-of-concept classrooms, or to push for rapid and radical change on a broader scale.

- *A key challenge is the fundamental structure of the K-12 education establishment.* As long as maintaining the basic elements of the existing system remains the focus of efforts to support education, there will be resistance to any profound change in practice. Learners have increasing opportunities to take their education into their own hands, and options like informal education, online education, and home-based learning are attracting students away from traditional educational settings. If the system is to remain relevant it must adapt, but major change comes hard in education.
- *Many activities related to learning and education take place outside the walls of the classroom — but these experiences are often undervalued or unacknowledged.* Beyond the classroom walls, students can take advantage of online resources, explore ideas and practice skills using games and other programs they may have on systems at home, and interact with their extensive — and constantly available — social networks. Within the classroom, learning that incorporates real life experiences like these is not occurring enough and is too often undervalued when it does take place. This challenge is an important one in K-12 schools, because it results in a lack of engagement in learning on the part of students who are seeking some connection between their world, their own lives, and their experience in school.

These trends and challenges are having a profound effect on the way we experiment with, adopt, and use emerging technologies. These aspects of the world that surround and permeate education serve as a frame for considering the probable impacts of the emerging technologies listed in the sections that follow.

Technologies to Watch

The six technologies featured in each *Horizon Report* are placed along three adoption horizons that indicate likely time frames for their entrance into mainstream use for teaching, learning, or creative applications in the K-12 environment. The near-term horizon assumes the likelihood of entry into the mainstream for schools within the next twelve months; the mid-term horizon, within two to three years; and the far-term, within four to five years. It should be noted that the *Horizon Report* is not a predictive tool. It is meant, rather, to highlight emerging technologies with considerable potential for our focus areas of teaching, learning, and creative expression. Each of them is already the focus of work at a number of innovative schools around the world, and the work we showcase here reveals the promise of a wider impact.

On the near-term horizon — that is, within the next 12 months — are *cloud computing* and *collaborative environments*. Both appeared in the *2009 Horizon Report: K-12 Edition*, and their reappearance here is an indication of continued interest in these technologies. Cloud computing, viewed in 2009 as two to three years away from mainstream adoption, has seen dramatic uptake by schools over the past twelve months — but only in one of its forms. Schools commonly use cloud-based applications today, but the promise of the cloud's extensive resources for computation, research, and collaborative work has yet to be realized. Similarly, collaborative environments appear again, and remain on the near-term horizon, as a reflection of their importance to education and of the fact that they have been adopted in part, but not to the full extent of their potential.

- **Cloud computing** has transformed the way we think about computing and communication, data storage and access, and collaborative work. Cloud-based applications and services are available to many school students today, and more schools are employing cloud computing solutions all the time. What still remains to be developed is the capacity for the cloud to help students engage in real research and participate in global learning communities.
- **Collaborative environments** can be complete, off-the-shelf packages or collections of do-it-yourself tools, depending on the level of comfort of the teachers and support personnel and the needs of the students using the systems. Whatever tools are chosen, collaborative environments give students tremendous opportunities to interact with peers and mentors, experience other worldviews, and model the kinds of work patterns that take place in an increasing number of professions.

The second adoption horizon is set two to three years out, where we will begin to see widespread adoptions of two well-established technologies: *game-based learning* and *mobiles*. Both games and mobiles have clearly entered the mainstream of popular culture; both have been demonstrated as effective tools for learning in a number of schools already; and both are expected to see much broader use in pre-college education over the next two to three years. Mobiles make a repeat appearance this year. While the Advisory Board acknowledges their great potential for learning, the reality is that the use of mobiles continues to be restricted by policies that prevent many schools from taking advantage of them as tools for teaching and learning.

- Interest in **game-based learning** has grown in recent years as research continues to demonstrate its effectiveness for learning. Games for education span the range from single-player or small-group card and board games all the way to massively multiplayer online games

and alternate reality games. Those at the first end of the spectrum are easy to integrate with the curriculum, and in many schools they are already an option; but the greatest potential of games for learning lies in their ability to foster collaboration and engage students deeply in the process of learning. For a variety of reasons, the realization of this potential is still two to three years away.

- The story of **mobiles** is no longer about the devices themselves, but about the blurring of the boundary between the cellular networks and the Internet. Increasingly, and more so in the developing world, the Internet is accessed from mobile devices using a cellular network that extends significantly beyond even the electric grid. Mobiles represent an untapped resource for reaching students and for bridging the gap between the learning that happens in school and the learning that happens out in the world.

On the far-term horizon, set at four to five years away from widespread adoption, are *augmented reality* and *flexible displays*. Neither of these two technologies is commonly found in school settings, but the high level of interest and the tremendous amounts of research in both areas indicate that they are worth following closely.

- **Augmented reality (AR)** has become something anyone can use, thanks to the convergence of three technologies — GPS, video, and pattern recognition — and the applications seem endless. Combined with mobile technology, AR becomes a portable tool for discovery-based learning, enhancing the information available to students when visiting historical locations, doing field work, interacting with real-world objects, and even paging through books.
- **Flexible displays** are seen as an important enabling technology in development, and those that exist today hint at what will be possible in coming years. Thin screens will eventually be embedded in books, attached to desks and walls, and integrated with all kinds of objects.

Touch-based interfaces and flexible displays are converging in interesting ways; though applications for schools are still several years away, we can expect to see integrated interactive displays becoming part of many common objects in the not-so-distant future.

Each of these technologies is described in detail in the body of the report. These sections open with a discussion of what the technology is and why it is relevant to teaching, learning, and creative inquiry. Examples of the technology in practice, especially in schools, are listed there to illustrate how it is being adopted at the current time. Our research indicates that all six of these technologies, taken together, will have a significant impact on learning-focused organizations within the next five years.

The Horizon Project

Since March 2002, under the banner of the Horizon Project, the New Media Consortium has held an ongoing series of conversations and dialogs with hundreds of technology professionals, campus technologists, faculty leaders from colleges and universities, teachers and other school professionals, and representatives of leading corporations from more than two dozen countries. In the ensuing years, these conversations have resulted in the publication each January of a report focused on emerging technologies relevant to higher education. At the center of the process is an international advisory board whose role is ultimately to select the topics in the report, via a consensus-based process. As they work, the Advisory Board engages in lively dialogs around a wide range of articles, published and unpublished research, papers, scholarly blogs, and websites. The result of these dialogs is a list of the key technologies, trends, challenges, and issues that knowledgeable people in technology industries, higher education, and learning-focused organizations are thinking about.

In 2008, the NMC embarked on a new series of regional and sector-based companion editions of the *Horizon Report*, with the dual goals of understanding

how technology is being absorbed using a smaller lens, and also noting the contrasts between technology use in one area compared to another. This report, the *2010 Horizon Report: K-12 Edition*, is the second in the series focusing on pre-college education. To date, companion editions have been prepared that center on Australia and New Zealand, on the K-12 sector, and on small- to medium-sized businesses. The flagship *Horizon Report*, focused on higher education, is translated into multiple languages every year. Over all editions, the readership of the reports is estimated at over 500,000 worldwide, with readers in more than 50 countries.

Like the university-focused effort from which it emerged, the K-12 project, referred to informally as Horizon.K12, uses qualitative research methods to identify the technologies selected for inclusion in the report, beginning with a survey of the work of other organizations, a close examination of topics previously detailed in the *Horizon Report* series, and a review of the literature with an eye toward spotting interesting emerging technologies. When a new cycle is started, little is known, or even can be known, about the appropriateness or efficacy of many of the emerging technologies for these purposes, as the Horizon Project expressly focuses on technologies not currently in widespread use in schools.

By engaging a wide community of interested parties, and diligently searching published research, the Internet, and other sources, enough information is gathered early in the process to allow the members of the Advisory Board to form an understanding of how each of the discovered technologies might be in use in settings outside of education, to develop a sense of the potential the technology may have for educational settings, and to envision applications of the technology for teaching, learning, and creativity. The findings are discussed in a variety of settings — with teachers, industry experts, technologists, and of course, the Horizon Advisory Board. Of particular interest to the Advisory Board every year is finding educational applications for these technologies that may not be intuitive or obvious.

The 42 members of this year's K-12 Advisory Board were purposely chosen to represent a broad spectrum of K-12 education, as well as key writers and thinkers from business and industry. They engaged in a comprehensive review and analysis of research, articles, papers, blogs, and interviews; discussed existing applications, and brainstormed new ones; and ultimately ranked the items on the list of candidate technologies for their potential relevance to teaching, learning, and creative expression. This work took place entirely online and may be reviewed on the project wiki at <http://k12.wiki.nmc.org>.

The work does not stop there, however. In 2010, the Consortium for School Networking, in collaboration with HP, is preparing a K-12 toolkit to accompany the report, aimed at school and district leaders, board members, policymakers, teacher groups, and others. The toolkit, to be released under a Creative Commons license, will help these key groups maximize the impact of the report in their schools and help their constituencies gain an understanding of new applications of technology to support teaching and learning and successfully plan for their implementation.

Each *Horizon Report* is produced over a period of just a few months so that the information is timely and relevant. This year, the effort to produce the K-12 report began at the end of January 2010 and concluded when the report was released in early April 2010, a period of under three months. The six technologies and applications that emerged at the top of the final rankings — two per adoption horizon — are detailed in the chapters that follow.

Each of those chapters includes detailed descriptions, links to active demonstration projects, and a wide array of additional resources related to the six profiled technologies. Those profiles are the heart of the *2010 Horizon Report: K-12 Edition*, and will fuel the work of the Horizon Project throughout 2010-11. For those wanting to know more about the processes used to generate the *Horizon Reports*, many of which are ongoing and extend the work in the reports, we refer you to the report's final section on the research methodology.

CLOUD COMPUTING

Time-to-Adoption Horizon: One Year or Less

The “cloud” refers to surplus computing resources available from specialized data centers, each often hosting thousands of servers, that power the world’s largest websites and web services. Growing out of research in grid computing, cloud computing transforms once-expensive resources like disk storage and processing cycles into a readily available, cheap commodity. Development platforms layered onto the cloud infrastructure enable thin-client, web-based applications for image editing, word processing, social networking, and media creation. Many of us use the cloud, or cloud-based applications, without even being aware of it. In schools, use of cloud computing is progressing along a path that began with the adoption of collaborative tools for administrative tasks and that leads, eventually, to classroom adoption of cloud-based tools for learning.

Overview

The cloud is the term for the myriad of servers and other computers that power the Internet. Cloud applications harness the unused resources of these computers to distribute applications, storage, and even processing power to users in ways that are increasingly useful, low cost, and ubiquitous. Cloud-based applications use storage space and computing resources from many available machines as needed. “The cloud” denotes any group of computers used in this way. Cloud computing currently includes three broad areas of development: cloud-based applications, which are designed for many different tasks and hosted in the cloud; development platforms for creating cloud-based applications; and massive computing resources for storage and processing.

Most people are familiar with the first type: applications that serve a single function, such as Gmail or Quicken Online, that are generally accessed through a web browser and that use the cloud for processing power and data storage. The second group of services offer the infrastructure on which such applications are built and run, along with the computing power to deliver them. Examples include Google App Engine, which allows developers to create and host tailored programs using Google’s infrastructure; Heroku, which does the same for applications developed in Ruby on Rails; and Joyent, which hosts and scales applications in a variety of languages. The final set of cloud services are those that offer sheer computing resources without a development platform layer, like

Amazon’s Elastic Compute Cloud or the GoGrid. These resources are often used for intensive computing and research tasks.

Many of the technologies we use every day — and many featured in this edition of the *Horizon Report* — are supported by the cloud. Collaborative environments and tools are cloud applications; mobile applications are often hosted in the cloud; augmented reality applications, especially those that run on mobile devices, are often cloud-based as well. One of the advantages of cloud computing is that it makes it possible to deploy tools that can scale on demand to serve as many users as desired, and then scale back to conserve resources when usage levels drop. Applications that offer online storage, like Dropbox, Flickr, and others, use cloud solutions to provide inexpensive space. As a result, the cloud has become well established as an infrastructure for computing and communication.

Regular readers will have observed that cloud computing appeared in the *2009 Horizon Report: K-12 Edition*, where it was placed on the mid-term horizon. While it was difficult to find examples of the use of cloud computing in schools a year ago, there are now many, many schools that have adopted cloud-based tools for productivity, scheduling, curriculum development, and collaboration, at least at the administrative level. This shift has moved cloud computing firmly into the near horizon for 2010, although we have yet to see significant adoption of

some of the most promising advantages of cloud computing, such as using collaborative cloud-based media authoring tools for student work, or participating in large-scale research efforts that use the power of inexpensive parallel processing made available by the cloud.

Relevance for Teaching, Learning, or Creative Expression

Cloud computing can offer significant cost savings in terms of IT support, software, and hardware expenses. It has become common for schools to use cloud-based applications to manage calendars, rosters, grade books, and communication between school and home. Examples of student use of cloud resources, however, are more rare. Adoption of cloud-based tools at the administrative level is a promising sign that schools are approaching the point where they can take advantage of the opportunities these tools offer for teaching and learning. Some schools, like Columbia Secondary School in New York, have adopted cloud solutions to facilitate student work in engineering, English, debate, and other subjects. At CSS, students use Google Spreadsheets to learn budgeting, and work on peer review and editing of their writing projects using Google Docs.

Minnesota Online High School, which serves over 300 remote students, recently made the shift to cloud computing, using a suite of applications including a learning management system and applications for coursework, homework, school services, and personal files. The change freed the school from having to press, ship, and inventory software CDs and made it easier for their IT support staff to assist students, who use a wide range of computer platforms. Similarly, iLab Central is a project funded by the NSF through MIT and Northwestern University that provides remote access to sophisticated labs and scientific testing equipment for high school students.

Teachers of some STEM courses have partnered with universities and other centers to access higher-end computing resources to enable students to work on complex projects involving scientific research data

that desktop computers are unable to process. North Carolina State University, for example, is working with IBM to provide cloud applications, computing power, and storage space to every public school in the state. In the fall of 2009, IBM announced the IBM Cloud Academy, a group of schools, universities, and other learning organizations dedicated to discovering and promoting ways to use the cloud in education. The group includes school districts as well as universities from around the world. Their goals include finding ways for school students to participate in research projects using cloud resources.

The value of cloud computing as a way to provide access to services and tools without the need to invest in additional infrastructure makes it an attractive option for many schools. Additionally, the fact that cloud applications can be accessed from a variety of devices, including not only desktop and laptop computers but many mobile devices as well, positions cloud computing as a solution that can help to fill existing gaps in school technology while making the most use of already available resources.

A sampling of applications of cloud computing across the curriculum includes the following:

- **English.** At West Springfield High School in Springfield, Massachusetts, English classes use Adobe Buzzword to create, edit, and review writing assignments. The students find it easier and more fun to comment on one another's papers using the tool.
- **History.** ArcGIS Online, developed by ESRI, includes a suite of web-based mapping tools that are used across the curriculum. As one example, history teachers use the tools to quickly create custom maps of battles, journeys, and other significant events.
- **School Services.** Coleman Tech Charter High School, scheduled to open in September 2010 in San Diego, has integrated cloud computing into the school's design from the ground up. Student work and activities will be facilitated by a range of cloud tools, a robust wireless internet

network will ensure that access is available anywhere on campus, and coursework will be accessible from any location for homebound or traveling students.

Cloud Computing in Practice

The following links provide examples of how cloud computing is being used in schools.

Clarkstown Central School District, New York

<http://docs.google.com/fileview?id=0B5AOHQcS-cAeZDA1N2QzZjctOGYzYS00YjZiLThkMWUtNTUxMTRhYTcwN2Mw&hl=en>

The Clarkstown Central School District uses Google Apps to coordinate curricula and resources within schools and across the district. Innovative uses of the calendar, shared documents, and shared sites makes it easy for teachers to follow district curriculum plans, keep up with school-related events, and create and share curriculum resources.

Cloud-Computing Infrastructure and Technology for Education (CITE)

<http://www-paoc.mit.edu/cmi/technologies/cloudcomputing.htm>

This project, from MIT's Climate Modeling Initiative, looks at ways to use cloud computing resources to perform scientific research, both in university labs and in K-12 classrooms.

Columbia Secondary School

http://www.google.com/a/help/intl/en/edu/case_studies/columbia.html

A partnership between the New York City Department of Education, Columbia University, and the Columbia Secondary School has led to the deployment of cloud-based systems including a custom content management system and Google Apps. The students are using these cloud applications to do research and to collaborate in new ways.

Infrastructure — The Highway to 21st Century Learning

<http://www.edtechmag.com/k12/events/updates/infrastructure-the-highway-to-21st-century-learning.html>

(John Kuglin, CIO, ECSD. *Ed Tech Magazine*.)

The Eagle County School District in Colorado is implementing a cloud computing system that will make tools for email, word processing, presentations, and calendaring accessible to everyone in the district.

Laboratory for Continuous Mathematical Education, St. Petersburg, Russia

<http://www.lcmespb.ru/>

This project, supported by an HP Innovations in Education grant, connects students with scientific researchers, giving them an opportunity to experience professional research practices while also building their own technical skills. The students work with researchers from both scientific and industrial professions.

TeacherTube

<http://www.teachertube.com>

This cloud-based video service is modeled after YouTube but is designed specifically for teachers, schools and homeschoolers. It offers a wide range of educational videos on a range of topics.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about cloud computing.

Above the Clouds: A Berkeley View of Cloud Computing

<http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.html>

(Michael Armbrust et al., Technical Report No. UCB/EECS-2009-28, 10 February 2009.)
The authors posit that cloud computing has

the potential to transform the IT industry by creating computing services with less risk of over- or under-provisioning based on fluctuating demand and by creating an elasticity of storage and processing resources.

Briefing: Cloud Computing

<http://www.technologyreview.com/briefings/cloud/>

(MIT Technology Review, *July/August 2009*.)

This article describes how cloud computing works and discusses its impact on various industries and professions.

Computing in the Clouds

http://www.learningandleading-digital.com/learning_leading/200912#pg18

(Doug Johnson, *Learning and Leading with Technology*, December/January 2009-10, pp. 16-20.) This article provides an overview of cloud computing and discusses how the technology can benefit schools.

The Start of a Tech Revolution

<http://www.districtadministration.com/viewarticle.aspx?articleid=2004>

(Kurt O. Dyril, *District Administration*, May 2009.)

This article summarizes how the use of cloud computing can have a positive financial impact for school districts.

What is Cloud Computing?

<http://www.cloudbook.net/directories/what-is-cloud-computing>

(Cloudbook, accessed March 5, 2010.) A number of short videos prepared by various professionals and researchers give an overview of, and some perspectives on, cloud computing.

Delicious: Cloud Computing

<http://delicious.com/tag/hzk10+cloudcomputing>

(Tagged by K-12 Horizon Advisory Board and friends, 2010.) Follow this link to find additional resources tagged for this topic and this edition of the *Horizon Report*. To add to this list, simply tag resources with “hzk10” and “cloudcomputing” when you save them to *Delicious*.

COLLABORATIVE ENVIRONMENTS

Time-to-Adoption Horizon: One Year or Less

Collaborative environments are online spaces where the focus is on making it easy to collaborate and work in groups, no matter where the participants may be. As the typical educator's network of contacts has grown to include colleagues who might live and work across the country, or indeed anywhere on the globe, it has become common for people who are not physically located near each other to collaborate on projects. In classrooms as well, joint projects with students at other schools or in other countries are more and more commonplace as strategies to expose learners to a variety of perspectives. Collaborative environments can be off-the-shelf or assembled from a wide variety of simple, free tools — the key is the interactions they enable, not the technologies they include.

Overview

Collaborative environments appeared in the 2009 *Horizon Report: K-12 Edition*, and remain on the radar for 2010. While they have been adopted by many schools, the technologies that support collaborative work are still considered to be among the most important for education. Typically, once a topic has appeared on the near-term horizon, it does not appear in a report again, but the Advisory Board clearly felt that collaborative environments continue to bear watching.

The definition of a collaborative environment has not changed significantly in the past year. The technologies that support collaborative work range from small tools for jointly creating a single product, such as Voicethread, to shared document editors like Adobe Buzzword, Google Docs, and Etherpad, to wikis and group blogging systems, all the way up to self-contained environments for collaboration, like Moodle, Ning, or PageFlakes. The free, single-purpose tools at one end of the spectrum can be assembled by teachers with a technological bent into a collaborative experience that includes live video, synchronous and asynchronous chat and discussion, media creation tools, and so forth. For those who are less technically-minded, the comprehensive platforms at the other end of the range offer a suite of tools that already work together and that can be easily integrated into day to day work. The downside of the more comprehensive solutions is cost, although there are a number of open source

solutions in this category as well, with Moodle being one of the most notable.

Collaborative environments support both the collaborative creation of content and also communication or sharing of existing content. Tools that enable the former are the most well known, and include familiar applications like wikis, Google Docs, and group or class blogs. Wikis were one of the first technologies in this category, and it is increasingly rare to find a collaboration that does not use a wiki in one form or another. The largest example in this category is Wikipedia, which through the efforts of thousands of contributors, has become the world's *de facto* encyclopedia. Other tools, like Kaltura, allow people to collaborate around the creation of rich media, including audio and video, and make it easy for members of a community to share, comment on, and remix content.

The second category reflects how online communication tools are converging with social media in workspaces like Ning, PageFlakes, and Moodle. These tools can be customized and personalized, and membership can be open or restricted, but the primary purpose is not joint content creation or remixes, but communication within a group. Some of these systems can be augmented by plug-in widgets that extend their capabilities even further, and that spring from the growing community of users and supporters of collaborative environments of all kinds. In these environments, the emphasis is on the

exchange of ideas and the sharing of knowledge. When these activities lead to action, tools from the first group (wikis, shared document editors, or joint multimedia authoring tools) are brought into play.

Still other collaborative environments are perhaps less customizable but come with tools already optimized for classroom use. One example is the Oracle Education Foundation's ThinkQuest (<http://www.thinkquest.org>), a free platform designed to support the creation of collaborative multimedia papers that makes it easy for students to blend photos, videos, and text in their research projects. Oracle hosts a competition for the best student work; the ThinkQuest Project Gallery is populated with over 7,000 entries touching on every classroom subject.

Relevance for Teaching, Learning, or Creative Expression

The value placed on collaboration in the workplace is high, and professionals of all kinds are expected to work across geographic and cultural boundaries more and more frequently. Teachers increasingly recognize the importance of collaboration skills and are finding that online tools to support collaboration provide them and their students with opportunities to work creatively, develop teamwork skills, and tap into the perspectives of people around the world with a wide range of experience and expertise that differs from their own. As a result, collaborative environments and workspaces are gaining a great deal of traction and are poised to enter mainstream use in primary and secondary education both as supplemental and as primary classroom spaces.

Systems expressly built for K-12 use often include built-in tools for scheduling, grading, communication, and other classroom tasks that make it easy to seamlessly integrate the environment. Even learning management systems like Moodle have begun to add social networking components. Many states offer virtual or online academies for the upper grades, and nearly all of these use collaborative environments for discussion, teaching classes, managing assignments, and other classroom tasks.

In some cases, students work entirely at home and attend class only online. In more traditional schools, teachers are finding that collaborative environments are an efficient way for students to work together, whether the groups are composed of students in the same physical class or not.

A class or project group can assemble a collaborative workspace very quickly using widgets that pull information from a range of sources. For instance, a custom class environment might include a calendar populated with data from the school's online calendaring system, an RSS feed that displays recent blog posts or Twitter updates from students and teachers in the group, a cloud of Delicious tags bookmarking web content related to the class or project, a Flickr badge that shows relevant rotating photos, and synchronous or asynchronous message boards. All the resources needed by the group can be accessed and added to by any of them, in a virtual space that is always available from any computer and many mobile devices.

One of the most compelling attributes of large-scale collaborative environments is that they can facilitate an almost spontaneous development of communities of people who share similar interests. As the typical educator's network of contacts has grown to include colleagues who might live and work across the country, or indeed anywhere on the globe, it has become common for people who are not physically located near each other to interact and share resources via online environments. Collaborative projects involving students at other schools, even in other countries, is more and more commonplace as a strategy to expose learners to a variety of perspectives. The Ning in Education collaborative space (<http://education.ning.com/>) is designed specifically to support its more than 9,000 members in using collaborative environments for teaching and learning.

A sampling of applications of collaborative environments across the curriculum includes the following:

- **Mathematics.** At Pleasant Street Primary School in Victoria, Australia, students created a collaborative environment dedicated to studying mathematics. Using collaborative tools including Voicethread and Ning, the students in the gifted and talented program developed an online textbook and workspace.
- **Cultural Studies.** Using the collaborative environment ThinkQuest, six students and two teacher coaches from the United States and Hungary created an interactive piece on the history of chocolate (see <http://library.thinkquest.org/08aug/00696/>). This piece took first place in the 2009 competition in the 15 and under category.
- **Science.** The Arctic Research Consortium of the United States (ARCUS) used the collaborative environment Wimba to connect K-12 students in 10 states with their teachers who were taking part in Arctic and Antarctic research expeditions. The teachers used both synchronous and asynchronous means of communication to work with their classes back home.

Collaborative Environments in Practice

The following links provide examples of how collaborative environments are being used in schools.

Backchannel with Etherpad Experiences

<http://www.speedofcreativity.org/2010/01/27/backchannel-with-etherpad-experiences/>

In this blog post, teacher Wesley Fryer describes how he used Etherpad to set up a backchannel — a supplemental discussion — for his Technology 4 Teachers class. The process Fryer describes is easily adaptable to other tools.

Cross-Cultural Collaboration: Students Bridge Cultures with Videoconferencing from Carnegie Hall

<http://thejournal.com/Articles/2009/08/19/Cross-Cultural-Collaboration-Students-Bridge-Cultures-with-Videoconferencing-from-Carnegie-Hall.aspx>

(Denise Harrison, *THE Journal*, 19 August 2009.) This article summarizes a collaborative social studies project that connected students in the United States with their peers in other countries, including India and Turkey. The students explored a variety of music from their respective cultures.

eLanguages

<http://www.elanguages.org/>

This international project facilitates collaboration between teachers and classrooms around the world. Teachers can select or propose projects for their classes to take part in, exchange ideas with other teachers, and share resources.

Examples of K-12 Class Nings

<http://angelacunningham.wordpress.com/2009/07/14/examples-of-class-nings/>

This is a collection of collaborative environments based on the Ning platform that are used by K-12 classes. The list is organized by subject and location and compiled by teacher Angela Cunningham.

The Flat Classroom Project

<http://flatclassroomproject.ning.com/>

The Flat Classroom Project connects teachers and students in middle and high school grades. The site provides tools and templates and assists teachers in finding collaborators from other schools to work on joint projects.

Kites Around the World

<http://globalkites.wikispaces.com/>

Kites Around the World is an international project for students to exchange ideas and information about kites. Students can explore kite design, learn how to build different kites, contribute videos of themselves flying their kites, and collaborate on creating descriptions of how kites are made and flown in their country.

Solar Navigations Wiki

<http://solar6voyages.wikispaces.com/>

Duke University Libraries has launched a mentoring program for Durham Public Schools to help them implement and use technology in the classroom. This particular project used a wiki to facilitate student collaboration between classes to create jointly-authored reports on the solar system.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about collaborative environments.

Digital Access, Collaboration a Must for Students

<http://www.eschoolnews.com/2010/03/16/digital-access-collaboration-a-must-for-students/>

(Laura Devaney, eSchool News, 16 March 2010.) This article describes the results of an educational technology survey undertaken by Project Tomorrow. The survey identifies a new type of student, the “free agent learner,” who takes greater responsibility for learning and uses technology tools to create personal learning experiences.

Educational Networking: The Important Role Web 2.0 Will Play in Education (PDF)

<http://audio.edtechlive.com/lc/>

EducationalSocialNetworkingWhitepaper.pdf

(Steve Hargadon, 16 December 2009.) This paper gives a broad overview of the importance of collaborative environments and their value in the K-12 educational space.

Howard Rheingold on Collaboration

http://www.ted.com/talks/howard_rheingold_on_collaboration.html

(Howard Rheingold, TED: Ideas Worth Spreading, February 2005.) In this talk from 2005, Howard Rheingold discusses the emerging world of collaboration, participatory media and collective action. His insights then are still pertinent today.

The Impact of Collaborative, Scaffolded Learning in K-12 Schools: A Meta-Analysis (PDF)

http://www.cisco.com/web/about/citizenship/socio-economic/docs/Metiri_Classroom_Collaboration_Research.pdf

(Susan M. Williams, The Metiri Group. Commissioned by Cisco Systems, September 2009.) This report discusses how collaboration environments can be implemented in schools and the impact they can have when integrated with existing systems.

The Impact of Social Computing on the EU Information Society and Economy (PDF)

<http://ftp.jrc.es/EURdoc/JRC54327.pdf>

(K. Ala-Mutka et al., Institute for Prospective Technological Studies, Joint Research Center, European Commission, November 2009.) This report gives a comprehensive overview of social computing and its impact in the European Union.

Jazz as an Extended Metaphor for Social Computing

<http://transliterations.english.ucsb.edu/post/research-project/research-clearinghouse-individual/research-reports/jazz-as-an-extended-metaphor-for-social-computing>

(Aaron McLeran, UC-Santa Barbara Transliterations Project, 17 May 2009.) This unusual study looks at social computing and jazz and finds some striking — and surprising — similarities between the two.

Keeping Pace with K-12 Online Learning (PDF)

[http://www.kpk12.com/downloads/](http://www.kpk12.com/downloads/KeepingPace09-fullreport.pdf)

KeepingPace09-fullreport.pdf

(John Watson, et al., Evergreen Education Group, November 2009.) This report discusses the state-level policy and practices for K-12 online learning across the United States.

Delicious: Collaborative Environments

<http://delicious.com/tag/hzk10+collabspace>

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GAME-BASED LEARNING

Time-to-Adoption Horizon: Two to Three Years

The interest in game-based learning has accelerated considerably in recent years, driven by clear successes in military and industrial training as well as by emerging research into the cognitive benefits of game play. Developers and researchers are working in every area of game-based learning, including games that are goal-oriented; social game environments; non-digital games that are easy to construct and play; games developed expressly for education; and commercial games that lend themselves to refining team and group skills. At the low end of game technology, there are literally thousands of ways games can be — and are already being — applied in learning contexts. More complex approaches like role-playing, collaborative problem solving, and other forms of simulated experiences have broad applicability across a wide range of disciplines, and are beginning to be explored in more classrooms.

Overview

Game-based learning is an expansive category, ranging from simple paper-and-pencil games like word searches all the way up to complex, massively multiplayer online (MMO) and role-playing games. Educational games can be broadly grouped into three categories: games that are not digital; games that are digital, but that are not collaborative; and collaborative digital games. The first category includes many games already common in classrooms as supplemental learning tools. Digital games include games designed for computers, for console systems like the Nintendo Wii, and online games accessed either through a special game client (like IBM's *Power Up*) or through a web interface (like *Whyville*).

The first digital games appeared with the first home computers in the early 1980s. Ten years later, the web was born, and games began to be delivered over the Internet. In 2003, the first full Internet service for mobile phones arrived in the US, bringing games to mobile devices. The three most recent cohorts of children — those born in the early 1980s, the early 1990s, and the early 2000s — have grown up in a world where digital games have always been an important part of their lives. Those born since the early 1990s have never lived in a world without a global network. The most recent kids to enter schools, those born since the early 2000s, have never known a world in which that global network was not accessible from the palm of your hand.

These three cohorts of kids define our school populations, and throughout their lives, they have always been immersed in the culture of digital games; it is like the air they breathe. The oldest of them are now becoming the teachers in our schools, and it will not be long before they also begin to fill out the administrative ranks. These young people continue to play games as adults: research has shown that the average age of a video gamer in the United States in 2009 was 35 years. As the UK's *Guardian* wrote in 2005, a game-player today is as likely to have children as to be a child. Games are a natural way to reach young people today, and a great deal more is now known about how to develop good games both for entertainment and for education.

Research into games for educational purposes reveals some interesting trends. Early studies of consumer games helped to identify the aspects of games that make them especially engaging and appealing to players of various ages and of both genders: the feeling of working toward a goal; the possibility of attaining spectacular successes; the ability to problem-solve, collaborate with others, and socialize; an interesting story line; and other characteristics. These qualities are replicable, though they can be difficult to design well, and they can transfer to games featuring educational content. We are discovering that educational content can be embedded in games rather than tacked on, and

that players readily engage with learning material when doing so will help them achieve personally meaningful goals.

A few years further out, but increasingly interesting, is the creation of massively multiplayer online (MMO) games designed for learning. Like their entertainment- or training-focused counterparts (*World of Warcraft*, *Everquest*, *Lord of the Rings Online*, *America's Army*, and others), games of this type bring many players together to work on activities that require collaborative problem-solving. Games like these are complex, and include solo as well as group content and goals that are collaborative as well as some that are competitive. They are often goal-oriented in ways that tie to a storyline or theme, but the highest levels of interaction and play require outside learning and discovery. What makes MMO games especially compelling and effective is the variety of sub-games or paths of engagement that are available to players — there are social aspects, large and small goals to work towards, often an interesting back story that sets the context, and more. Players dedicate enormous amounts of time on task pursuing the goals of these games. The problem that needs to be solved, and which is being tackled on many fronts today, is that of embedding educational content in such a way that it becomes a natural part of playing the game.

Relevance for Teaching, Learning, or Creative Expression

Educational games of some types have been in common use for some time, both in classrooms and at home. Many of these are single-player drill and practice games that can be played in 30- to 45-minute chunks and include explicit educational content, like *Reader Rabbit* or *Math Blaster*. Others, like the card game *Quiddler*, make use of key learning skills as part of game play — spelling and language, in this case. These games can be either non-digital, like the ecology-focused board game *Earthopoly*, or digital, and by and large, they are single-player or turn-based rather than truly collaborative. Subject mastery is generally emphasized over complex

problem-solving. These skill-building games and small group games that foster discussion and teambuilding are not difficult to fit into the curriculum, and many examples of their use can be found. Their engaging nature makes them excellent learning aids, as kids will often willingly play them much longer than they would otherwise study the material in question.

Online games for single users are also popular, though access to them is often blocked at school. There are many free games designed for K-12 students that are accessible via a web browser and require no installation, such as *The Potato Story* (<http://www.thepotatostory.co.uk>), a UK-based game that teaches kids where food comes from. Games in this class are essentially engaging tutorials that cover a particular topic in age-appropriate depth. In Singapore, games designed for the Nintendo Wii platform teach students about the history of Singapore as they aid the country's founders in solving problems that occurred as the nation was establishing itself.

The category of game-based learning that is still two to three years away for schools, but one that has tremendous potential to transform education, includes open-ended, challenge-based, truly collaborative games. Games like these, which occur in both massively multiplayer online (MMO) and non-digital forms, can draw on skills for research, writing, collaboration, problem-solving, public speaking, leadership, digital literacy, and media-making. When embedded in the curriculum, they offer a path into the material that allows the student to learn how to learn along with mastering, and truly owning, the subject matter. These games lend themselves to curricular content, requiring students to discover and construct knowledge in order to solve problems. They are challenging to design well, but the results can be transformative.

Although they are not often integrated in the classroom, game-based approaches like this have been used effectively in extracurricular programs like *Odyssey of the Mind*, *Destination ImagiNation*, and Math and Science Olympiads for some time.

These programs involve students in interdisciplinary problem-solving competitions that exercise and develop a wide range of skills. A digital counterpart to these activities is the Global Kids Gaming Initiative, which uses online games to promote digital literacy skills, global awareness, and citizenship among young people. Urban youth taking part in Global Kids' Playing 4 Keeps program create and play games about social issues of global significance. Designing and developing games is another way to bring games into the curriculum. Good game design involves research, creative thinking, the ability to envision both problems and solutions, and many other learning skills.

Open-ended, collaborative games also play out as alternate reality games (ARGs), in which players find clues and solve puzzles in experiences that blur the boundary between the game and real life. Recent examples of large-scale ARGs include the educational games *World Without Oil* and *Superstruct*, and the promotional game *I Love Bees. The Tower of Babel*, an ARG designed by the European ARGuing Project, was used in schools as well as by learners of all ages. It was developed to engage students in learning languages other than their own.

Another promising area for development is educational MMO gaming. As yet, there are few examples of these games designed specifically for education. Early efforts include *Mithril* (<http://stanford.edu/~pnaqlada/mithril>), a multiplayer online role-playing game developed by students at Stanford University. *Mithril* draws on the look and feel of MMOs but is math-based; players must master mathematical concepts in order to cast spells, defeat foes, and progress in the game.

As gaming and the science of engagement become better understood, we are likely to see significant investment in large-scale educational games. The compelling nature of MMO games in particular is attracting researchers and educators who appreciate the revolutionary power of including games in the

curriculum, though this is not the only area of gaming being explored. In New York City, a school named Quest to Learn (<http://www.q2l.org/>) has embedded games at the deepest levels of its infrastructure. Founded in 2009, the school currently includes grades 6 and 7 and plans to expand up to 12th grade. The school's curriculum is created using the principles of game design; in class, games and problem-based learning activities help students develop critical skills and literacies.

Research and experience are starting to show that games can clearly be applied very effectively in many learning contexts. Games can engage learners in ways other tools and approaches cannot, and their value for learning has been established through research. We know more about how games work and how to apply them to teaching and learning than we ever have, and that understanding is increasing. Education in general is still a few years away from embracing games as mainstream practice, but given the exciting results coming from game-based research, they are clearly a space to watch.

A sampling of applications of game-based learning across the curriculum includes the following:

- **The Arts.** Twenty schools in Victoria, Australia, used a drag-and-drop animation game to produce stories using backgrounds, characters, and objects from high-quality digital reproductions from *The Floating World*, the National Gallery of Victoria's collection of Edo period Japanese woodblock prints. The game was incorporated across the curriculum, touching on world language, cultural studies, English, and science as well as the arts.
- **Media Literacy.** The *World of Warcraft* (WoW) in School Project (<http://wowinschool.pbworks.com>) engages at-risk students at Suffern Middle School in New York and Cape Fear Middle School in North Carolina in an afterschool program that teaches skills in communication, digital literacy, online safety, mathematics, and leadership through game play.

- **World Languages.** Students at Keysborough Primary School in Victoria, Australia, used the 3D-world authoring tool Kahootz to produce a series of treasure hunt games demonstrating their understanding of giving and asking for directions in French. Students wrote their own dialogues in French and recorded them in their own voices.

Game-Based Learning in Practice

The following links provide examples of how game-based learning is being used in schools.

Arcademic Skill Builders: Online Educational Games

<http://www.arcademicskillbuilders.com/>

Arcademic Skill Builders offers free, Flash-based math and language arts games, aligned with current educational standards, for K-12 students.

GameDesk

<http://gamedesk.usc.edu>

Developed at the University of Southern California in collaboration with the Los Angeles Unified School District, GameDesk is an approach that combines project-based learning with engaging game design for high school students.

Mathematics In A Non-Mathematical Context, Porto, Portugal

http://www.es-garciadeorta.pt/projectos_matematica.html

Students work in small groups using laptops to design and develop their own projects for presentation at science fairs and other events. The project, supported by an HP Innovations in Education grant, helps foster collaboration, teaches problem solving and exposes students to the kind of interdisciplinary work that they will encounter in later life.

Scalable Game Design

<http://scalablegamedesign.cs.colorado.edu>

A collaboration between the University of Colorado's departments of Computer Science and Education, its Science Discovery Outreach Program, and AgentSheets, the Scalable Game Design project aims to teach computer science through game design at the middle school level. Students recreate well-known arcade games as well as developing their own games.

Urgent EVOKE

<http://www.urgentevoke.com/>

Urgent EVOKE is a collaborative online game that uses the principles of challenge-based learning to encourage young people to research and take action on issues of global significance. More than 13,000 players from all over the world, including several high school classes, are participating in the ten-week game at the time of this writing.

WhyReef

<http://www.whyville.net/smmk/top/gates?source=reef>

The online community *Whyville* is designed to help young students explore different topics, from recycling to programming. *WhyReef* teaches students about coral reef ecosystems.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about game-based learning.

Essential Facts about the Computer and Video Game Industry (PDF)

http://www.theesa.com/facts/pdfs/ESA_EF_2009.pdf

(*Entertainment Software Association, 2009.*) This report discusses trends, demographics and sales information about video and computer games in the United States based on survey data collected in 2008.

Deep Learning Properties of Good Digital Games: How Far Can They Go?

<http://www.jamespaulgee.com/node/37>

(James Paul Gee, Arizona State University, January 2009.) This study by noted educational games researcher James Paul Gee discusses the merits of good digital games and their design along with the learning that can accompany them.

Moving Learning Games Forward (PDF)

<http://education.mit.edu/papers/>

[MovingLearningGamesForward_EdArcade.pdf](#)

(E. Klopfer, S. Osterweil and K. Salen, *The Education Arcade*, MIT, 2009.) This white paper provides an overview of the current state of the field of game-based learning and proposes strategies for those wishing to enter the domain.

Using the Technology of Today, in the Classroom Today (PDF)

<http://education.mit.edu/papers/>

[GamesSimsSocNets_EdArcade.pdf](#)

(E. Klopfer, S. Osterweil, J. Groff, J. Haas, *The Education Arcade*, MIT, 2009.) This paper discusses effective learning in a gaming context and explores games as more than just single person experiences, but also part of social networks.

What Video Games Have To Teach Us About Learning and Literacy (book)

(James Paul Gee, Palgrave Macmillan, May 2003.) Gee examines the cognitive development that occurs during game play and considers the application of games to learning.

Delicious: Game-Based Learning

http://delicious.com/tag/hzk10+educational_games

(Tagged by K-12 Horizon Advisory Board and friends, 2010.) Follow this link to find additional resources tagged for this topic and this edition of the *Horizon Report*. To add to this list, simply tag resources with “hzk10” and “educational_games” when you save them to *Delicious*.

MOBILES

Time-to-Adoption Horizon: Two to Three Years

The mobile market today has more than 4 billion subscribers, more than two-thirds of whom live in developing countries. The global network supporting mobile devices of all kinds now covers more territory than the electrical grid. A massive and increasing number of people all over the world own and use computers that fit in their hand and are able to connect to the network wirelessly from virtually anywhere. Tens of thousands of applications designed to support a wide variety of tasks on a host of mobile devices and platforms are readily available, with more entering the market all the time. These mobile computing tools have become accepted aids in daily life for everything from business to personal productivity to social networking. The range and number of educational applications for mobiles are growing at a rapid pace, yet their use in schools is limited — more often constrained by policy than by the capabilities of the devices they run on.

Overview

The available choices for staying connected while on the go are many — smart phones, tablets, laptops, and over the coming year, the iPad and Slate PC will herald a new class of devices that blend the functions of all of them. Access to the Internet is less and less dependent on location, as users adopt cellular-based portable hotspots or the wi-fi that is increasingly available wherever people congregate. The devices we carry are becoming ever more capable, and the boundaries between them more and more blurred. In the developed world, mobile computing has become an indispensable part of day-to-day life in the workforce, and a key driver is the increasing ease and speed with which it is possible to access the Internet from virtually anywhere in the world via the ever-expanding cellular network.

Users increasingly expect anytime, anywhere access to data and services that not very long ago were available only while sitting in front of a computer linked to the network via a cable. In addition to the typical software for email, communication, and calendaring, new tools allow users to manage personal information (such as Evernote, Nozbe, Wesabe, and Triplt), collaborate and easily access and share files (Dropbox and CalenGoo are two of many possible examples), or keep abreast of social networks (Limbo, Facebook, Foursquare, Whrrl), and generally make checking and updating work, school, or personal information flows something easily done on the fly.

For many people all over the world, but especially in developing countries, where cellular access to the Internet is outpacing more traditional networks, mobiles are increasingly the gateway not only for common tools and communications, but also for information of all kinds, training materials, income-generating work, and more. An ever more common pattern is for people in all parts of the world to look to mobile computing platforms as their device of choice, as they are often far cheaper than desktop or laptop computers. For this group, mobile computing devices are more affordable, more accessible, and easier to use than desktop computers, and provide more than enough functionality to serve as their primary computing device.

A new class of devices emerging in 2010 will present a middle ground for those who need a little more flexibility and power from a mobile platform but do not want to carry a laptop or netbook. Made up of slim, lightweight devices that are neither small laptops nor large smart phones, this group includes the Apple iPad, the HP Slate, the Google Tablet, and others as yet unnamed that are forthcoming from Dell, Toshiba, and other manufacturers. While much remains to be seen about how these may be adopted and used, it is clear that their ability to connect wirelessly at any time and from almost any location, combined with a full range of features native to this new class, will make these devices a compelling option for mobile users.

Relevance for Teaching, Learning, or Creative Expression

The age at which students in the developed world acquire their first mobile device is dropping, and by secondary school, nearly every student has one. The portability of mobile devices and their ability to connect to the Internet almost anywhere makes them ideal as a store of reference materials and learning experiences, as well as general-use tools for field work, where they can be used to record observations via voice, text, or multimedia, and access reference sources in real time. Nonetheless, policies that ban mobile use in most schools keep this technology in the two- to three-year horizon for the second year running.

The range of technologies converging in mobile devices is very broad, as is the variety of ways they can be applied: GPS and compasses allow sophisticated location and positioning, accelerometers and motion sensors enable the device to be used in completely new ways, digital capture and editing bring rich tools for video, audio, and imaging — more and more, mobiles encompass it all.

Even so, it may well be the very simple tools that are easily integrated into classroom activities that finally tip the scale for mobiles in the classroom. For instance, some teachers are beginning to use Twitter (<http://www.twitter.com>) as an in-class discussion tool. Students participate by sending messages to ask and answer questions or expand on thoughts. Another simple tool, Poll Anywhere (<http://www.pollanywhere.com>), turns mobiles into personal response systems, enabling teachers to quiz students, assess their understanding before, during, and after a lesson, and reveal patterns of thinking in the classroom. Any mobile will work for either of these purposes; all that is required is the ability to send text (SMS) messages.

Another function common to many mobile devices, yet very powerful in the service of education, is the ability to store and display full-length books. The device used is secondary to the fact that it makes

it possible to carry a library of books — literature, textbooks, children's books, novels — easily in a pocket or purse. Students can use virtual bookmarks to mark important pages, highlight and annotate passages, look up words, and perform other common study tasks right on the mobile device.

The unprecedented evolution of these devices continues to generate great interest. Their ever-increasing capabilities are augmented by the reality that schools do not have to buy or maintain them. Over time, the vast potential of these devices for learning will begin to outweigh concerns about misuse that currently dominate most conversations about their use in school settings. It is the sheer power of these devices that make them interesting, and that power lies in their ubiquity, their portability, the wide range of things that can be done with them, and their ability to access the Internet nearly anywhere through the growing cellular network.

A sampling of applications for mobiles across the curriculum includes the following:

- **Geography.** At Clementi Town Secondary School in Singapore, mobiles support student field studies in geography. Upon arrival at the field site, instructions appear on the mobiles, and students work collaboratively to carry out experiments, take notes, analyze and synthesize data, and submit their results.
- **English.** Students can read their assignments and take notes on mobile devices. Notes can be uploaded to a computer by email or text message for use when writing papers.
- **Math.** Skills that require drill and practice lend themselves to mobile study. Students can get in a few minutes of practice wherever they are — and as many of these applications have a game-like feel, they may not even mind the drills.

Mobiles in Practice

The following links provide examples of how mobiles are being used in schools.

Essa Academy (Bolton, Greater Manchester, UK)

<http://www.essaacademy.org>

The Essa Academy is itself an evolving mobile computing learning environment. The campus has replaced desktop computers with laptops and issued iPod Touches to each student, encouraging flexible and collaborative learning practices facilitated by mobile technology (this article in *MerlinJohnOnline* gives additional details: <http://bit.ly/aAxU0>).

The Florida Virtual School: iPhone Apps

<http://www.flvs.net/areas/studentservices/Pages/iPhoneApps.aspx>

The Florida Virtual School has developed two iPhone apps to assist students in reviewing study material. MeStudying: Algebra 1 is an in-depth review tool for algebra students, including sample problems, guided study aids, and practice tests; Revu4U is a testing and review app that currently also covers algebra but will soon include other subjects as well.

Handheld Learning Conference Awards 2009

<http://www.handheldlearning2009.com/awards/the-finalists>

These awards are given at the annual Handheld Learning Conference to Primary and Secondary schools who have done innovative projects involving mobile devices. The conference is international in scope and this link provides a list of the 2009 award winners.

International Children's Digital Library (ICDL)

<http://en.childrenslibrary.org>

The mission of the ICDL Foundation is to support the world's children in becoming effective members of the global community by making the best in children's literature available online free of charge. They have two iPhone apps for reading and creating books which are available for free in the iTunes App Store.

Serious Games as Mobile Learning At School

http://www.futurelab.net/blogs/marketing-strategy-innovation/2009/10/serious_games_mobile_learning_.htm

The Notre Dame High School in Sheffield, UK will soon allow all students to use cell phones at school in addition to other mobile computing devices as the line blurs between these technologies.

The Use of Mobiles to Analyze Music

<http://www.pbs.org/teachers/innovators/gallery/entries/558/>

This middle school project was recognized by PBS as an innovative effort to have children use cell phones to help analyze different musical styles and genres.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about mobiles.

Apple's iPad: The Future of Mobile Computing in Education?

<http://campustechnology.com/articles/2010/01/27/apples-ipad-the-future-of-mobile-computing-in-education.aspx>

(*Dian Schaffhauser*, Campus Technology, 27 January 2010.) This article discusses mobile technology and the way it will affect education once new devices like the iPad arrive.

How the Cell Phone is Reinventing Social Computing

http://www.gemalto.com/social_mobility/survey.html

(*Gemalto.com*, accessed 12 March 2010.) This short summary of several industry surveys gives some insight into the use of mobile devices for social networking as well as some statistics about mobile usage in different areas of the world.

The iPad Changes Everything

<http://brainstormtech.blogs.fortune.cnn.com/2010/03/10/the-ipad-changes-everything/>

(Michael V. Copeland, *Fortune*, 10 March 2010.)

This article examines how devices like the Apple iPad will change our idea of mobile computing.

Making the Case for Mobile Computing

<http://www.edweek.org/dd/articles/2009/06/29/04neccmobile.h02.htm>

(Kathleen Kennedy Manzo, *Education Week Digital Directions*, 26 June 2009.) This article discusses the merits and challenges of mobile computing in the K-12 classroom.

Sprint Mobile Learning in K-12 Education

<http://www4.sprint.com/whitepapers>

(Sprint, February 2010.) One of several white papers listed on this page, *Sprint Mobile Learning in K-12 Education* looks at several school pilot programs in the United States and examines how the use of mobile phones has improved student engagement and test scores.

Teaching with Technology face-off: iPhones vs. PCs

<https://chronicle.com/blogPost/Teaching-With-Technology/4547>

(Jeffrey R. Young, *The Chronicle of Higher Education*, 25 February 2009.) One college professor found that students with access to an iPhone studied more than those who used only a PC.

Delicious: Mobiles

<http://delicious.com/tag/hzk10+mobile>

(Tagged by K-12 Horizon Advisory Board and friends, 2010.) Follow this link to find additional resources tagged for this topic and this edition of the *Horizon Report*. To add to this list, simply tag resources with “hzk10” and “mobile” when you save them to *Delicious*.

AUGMENTED REALITY

Time-to-Adoption Horizon: Four to Five Years

While the capability to deliver augmented reality experiences has been around for decades, it is only very recently that those experiences have become easy and portable. Advances in mobile devices as well as in the different technologies that combine the real world with virtual information have led to augmented reality applications that are as near to hand as any other application on a laptop or a smart phone. New uses for augmented reality are being explored and new experiments undertaken now that it is easy to do so. Emerging augmented reality tools to date have been mainly designed for marketing, social purposes, amusement, or location-based information, but new ones continue to appear as the technology becomes more popular. Augmented reality has become simple, and is now poised to enter the mainstream in the consumer sector.

Overview

The concept of blending (augmenting) virtual data — information, rich media, and even live action — with what we see in the real world, for the purpose of enhancing the information we can perceive with our senses is a powerful one. The first applications of augmented reality (AR) appeared in the late 1960s and 1970s. By the 1990s, augmented reality was being put to use by a number of major companies for visualization, training, and other purposes. Now, the technologies that make augmented reality possible are powerful and compact enough to deliver AR experiences to personal computers and mobile devices. Early mobile applications began to appear in 2008, and several augmented reality mapping and social tools are now on the market.

Wireless applications are increasingly driving this technology into the mobile space where they offer a great deal of promise. Initially, AR required unwieldy headsets and kept users largely tethered to their desktop computers. The camera and screen embedded in smart phones and other mobile devices now serve as the means to combine real world data with virtual data; using GPS capability, image recognition, and a compass, AR applications can pinpoint where the mobile's camera is pointing and overlay relevant information at appropriate points on the screen.

Augmented reality applications can either be marker-based, which means that the camera must perceive a specific visual cue in order for the software to call

up the correct information, or markerless. Markerless applications use positional data, such as a mobile's GPS and compass, or image recognition, where input to the camera is compared against a library of images to find a match. Markerless applications have wider applicability since they function anywhere without the need for special labeling or supplemental reference points.

Currently, many augmented reality efforts are focused on entertainment and marketing, but these will spill into other areas as the technology matures and becomes even more simplified. Layar (<http://layar.com>) has been a leader in this space with AR applications for Android and iPhones. Layar's mobile application features content layers that may include ratings, reviews, advertising, or other such information to assist consumers on location in shopping or dining areas. Other mobile applications that make use of AR for social or commercial purposes include Yelp, another review and rating service; Wikitude, which overlays information from Wikipedia and other sources onto a view of the real world; and a handful of Twitter clients. The mobile media company Ogmento develops AR games for mobiles.

The improvement in technology allows more streamlined approaches and wider user adoption. Market projections for augmented reality on mobile devices predict revenues of \$2 million in 2010, rising to several hundred million by 2014 (\$350 million, according to ABI Research; Juniper Research's

projections are even higher). Augmented reality is already entering the mainstream in the consumer sector, and the social, gaming, and location-based applications that are emerging point to a strong potential for educational applications in the next few years.

Relevance for Teaching, Learning, or Creative Expression

Emerging augmented reality tools to date have begun to overlay marketing, amusement, and location-based information over real-time video, and new applications continue to appear as the technology becomes more popular. Tools that illustrate how learning applications might overlay information over a video image of an historical site, or an artifact in a museum can already be found.

Augmented reality has strong potential to provide both powerful, contextual, *in situ* learning experiences and serendipitous exploration and discovery of the connected nature of information in the real world. Most of the activity happening in this area is taking place in universities, but the work going on there can easily be transferred to K-12 settings. (Augmented reality also appears in the university-focused *2010 Horizon Report*, where it was placed on the mid-term horizon to reflect its more rapid adoption at the college level.)

Applications that convey information about a place open the door to discovery-based learning. Students on field trips to historic sites can access AR applications that overlay maps and information about how the location looked at different points of history. An application currently in development by the EU-funded iTacitus project (<http://itacitus.org/>) will allow visitors to pan across a location — the Coliseum, say — and see what it looked like during an historical event, complete with cheering spectators and competing athletes. SREngine, another augmented reality application in development, will use object recognition to display information about everyday things one encounters in the real world — describing the use of different pieces of equipment in a dentist's

office, for instance, or identifying trees on a nature walk.

Augmented books, now just beginning to enter the market, are another interesting application of this technology. Zooburst (<http://www.zooburst.com>) is an authoring tool that allows students to create their own augmented reality storybooks. The German company Metaio (<http://www.metaio.com/demo>) is developing books that include AR elements, such as globes that pop up on the pages of a book about the earth. The books are printed normally. Then, after purchase, consumers install special software on their computers and point a webcam at the book to see the visualizations. The technology allows any existing book to be developed into an augmented reality edition after publication; an atlas featuring 3D views of geographic locations is currently in development.

A sampling of applications of augmented reality across the curriculum includes the following:

- **History.** Augmented reality can be used to model objects, allowing students to envision how a given item would look in different settings. Students studying the California missions, Byzantine architecture, or other structures could create detailed models to accompany in-class presentations.
- **Science.** The mobile application pUniverse turns a mobile device into a portable planetarium, overlaying data about celestial objects as the student pans the device around the sky.
- **Language Arts.** At Crossroads South Middle School in New Jersey, seventh- and eighth-grade students created AR costumes for characters in *A Midsummer Night's Dream*. The students drew the costumes, then “became” the characters as they acted out the play in front of a camera.

Augmented Reality in Practice

The following links provide examples of current projects that demonstrate the potential of augmented reality.

Arhrrrr - An Augmented Reality Shooter

<http://www.youtube.com/watch?v=cNu4CluFOcw>

This video demonstrates an augmented reality game created at Georgia Tech Augmented Environments Lab and the Savannah College of Art and Design Atlanta. The dynamic, interactive game uses a handheld mobile device, a table map — and Skittles candies.

ARIS Mobile Media Learning Games

<http://arisgames.org>

ARIS is an alternate reality gaming engine created by the University of Wisconsin's Games, Learning and Society research group. Virtual objects and characters can be placed at certain locations in the physical world; players can interact with them using their mobile devices.

ARSights

<http://www.arsights.com>

ARSights uses locations and structures in Google Earth to project augmented reality models of historical buildings and sites. Students can take virtual field trips, looking at three-dimensional models from different angles while seeing where on the globe they are actually located.

eTreasure

<http://www.etreasure.ch/site/>

eTreasure is an augmented reality team-based urban game used for teaching cultural heritage to grade school students in Switzerland. The game is developed by Webatelier.net, a laboratory of the University of Lugano.

Flynn Park Elementary School LIONS Program

<http://www.litzsinger.org/flynnpark.html>

Working with the Litzsinger Road Ecology Center near St. Louis, Missouri, Flynn Park Elementary participated in an NSF-funded grant program (Local Investigations of Natural Science, LIONS) to build and play augmented reality games in science and history. (For more detail on the grant program, see <http://www.glsconference.org/2008/session.html?id=42>).

LearnAR (Specialists Schools and Academies Trust)

<http://www.learnar.org/>

This UK-based project, designed for secondary students, includes 3D augmented reality models for several subjects, including biology, world languages, physics and religion. Students from subscribing schools can print out AR markers that then can display intricate 3D models for further examination.

Scimorph

<http://scimorph.greatfridays.com>

Scimorph is an augmented reality learning game designed to stimulate discussion among grade-school students and their teachers around the scientific issues dealt with in the game's scenarios. Scimorph is an alien that students can place into different environments to observe what happens.

Wikitude World Browser

http://www.wikitude.org/world_browser

With the Wikitude World Browser, students can view their surroundings through the camera on a mobile device, seeing historical information, nearby landmarks, and points of interest. Content is drawn from Wikipedia, Qype, and Wikitude, and students can add information of their own.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about augmented reality.

Augmented Learning: An Interview with Eric Klopfer (Part One)

http://henryjenkins.org/2008/07/an_interview_with_eric_klopfer.html

(*Henry Jenkins*, Confessions of an Aca-Fan, 7 July 2008.) Henry Jenkins interviews AR game developer Eric Klopfer, who gives insights into why this area of AR has promise in education and beyond. A link to part two is available on the above page.

Augmented Reality Technology Brings Learning To Life

<http://www.gse.harvard.edu/blog/uk/2009/09/augmented-reality-technology-brings-learning-to-life.html>

(Chris Dede, Usable Knowledge: Harvard Graduate School of Education, September 2009.) This article deals with educational uses for augmented reality, particularly in the middle grades, and discusses its potential to engage students. The article also touches on curriculum development for AR in the classroom.

If You Are Not Seeing Data, You Are Not Seeing **<http://www.wired.com/gadgetlab/2009/08/augmented-reality/>**

(Brian Chen, Wired Gadget Lab, 25 August 2009.) This Wired article gives a good overview of augmented reality, including where it currently is situated and what to expect in the future.

Map/Territory: Augmented Reality Without the Phone

<http://radar.oreilly.com/2009/08/mapterritory-augmented-reality.html>

(Brady Forrest, O'Reilly Radar, 17 August 2009.) This brief interview discusses what forms augmented reality might take beyond its application for mobile devices.

Visual Time Machine Offers Tourists a Glimpse of the Past

<http://www.sciencedaily.com/releases/2009/08/090812104219.htm>

(ScienceDaily, 17 August 2009.) New applications for smart phones offer augmented reality on the go. While on location, visitors view historical sites as they were hundreds of years ago.

Delicious: Augmented Reality

<http://delicious.com/tag/hzk10+augmentedreality>
(Tagged by K-12 Horizon Advisory Board and friends, 2010.) Follow this link to find additional resources tagged for this topic and this edition of the *Horizon Report*. To add to this list, simply tag resources with “hzk10” and “augmentedreality” when you save them to *Delicious*.

FLEXIBLE DISPLAYS

Time-to-Adoption Horizon: Four to Five Years

Computer displays continue to develop in ways that are enabling whole new categories of devices. Flexible screens that can wrap around curved surfaces are in prototype, as are small, very thin interactive screens. Flexible screen technology allows displays to be literally printed onto plastic, along with the batteries that power them, enabling the sorts of live motion displays previously only hinted about in the world of Harry Potter. When the technology is developed fully it will enable integrated interactive display devices that combine input and output in a single interface, finally realizing the full potential of electronic paper, though widespread commercial use remains several years away.

Overview

Still in the early stages of development, flexible displays are essentially very thin display screens — as thin as a credit card — that can be printed onto flexible or stretchable material and then attached to other surfaces or produced in a variety of shapes. Because these displays are printed, rather than developed using the clean-room etching processes necessary to create computer chips, they can be produced very cheaply and easily. The materials they can be printed on can roll, bend, flex, and stretch, lending themselves to curved or contoured surfaces. Already in the marketplace is Americhip's Video-in-Print, very thin flexible displays that can be easily inserted into popular magazines. CBS and *Entertainment Weekly* were first to demonstrate this new technology in the fall of 2009, when an issue of the magazine containing an embedded screen showing video promos for the CBS fall lineup was delivered to subscribers in New York and Los Angeles.

One of the underlying technologies that is enabling flexible displays is organic light-emitting diode (OLED) technology, which is already in use in several other areas. Manufacturers like Sony, Phillips, and Samsung are using OLED technology in slim television screens and are also experimenting with prototypes of flexible and ultra-thin OLED screens. Household lights using OLEDs produce more light using less power than the most efficient non-OLED bulbs currently available. Displays made with OLED screens can be very thin and draw very little power because the pixels that make up the screens emit

their own light, and a separate light source is not required. The screens are bright, like traditional displays, and can be layered onto plastic, although the process of printing the screens onto flexible plastic is still in the very early prototype stage. Current manufacturing processes also restrict the size of these flexible screens to no more than about six diagonal inches; larger screens, and even very large screens are technically possible, but currently cost-prohibitive.

Another supporting technology is flexible organic flash memory, which is used today in small devices such as cameras and MP3 players. Flash memory can hold information for a long time without continued electrical power, but finding a way to build flash memory into thin plastic has been problematic until very recently. Flexible organic flash memory will enable very thin touch-sensitive displays, but is still in very early development.

At the Arizona State University Flexible Display Center (FDC; <http://flexdisplay.asu.edu/>), researchers are working with HP, Boeing, the US Department of Defense, and others to bring this technology to the market in a variety of ways. The FDC was established in 2004 expressly for the purpose of developing the next generation of displays, emphasizing flexibility, low power costs, and sturdiness. In fact, the flexible displays currently in development and testing are extremely rugged, as demonstrated in test videos (see <http://www.youtube.com/watch?v=R2pV-SArGSM>). The wide range of industries interested

in flexible display technology is a strong indication that the early prototypes we are seeing now herald further development and progress.

The possibilities suggested by flexible displays are very interesting, though still somewhat distant in time. When this technology matures, we will see a new class of devices incorporating these displays that are smaller and more portable than ever before. They could very easily be integrated with everyday objects, such as tools, appliances, printed materials, and even clothing — turning those objects into context-specific data displays. Portable devices might emerge that feature displays that can be folded, rolled, or otherwise stored in small spaces. The future of flexible screens is still unfolding, but examples that have already appeared in advertising and entertainment channels hint at the range of coming applications.

Relevance for Teaching, Learning, or Creative Expression

Flexible displays, because of their adaptability and low cost, are certain to become part of everyday educational materials like periodicals, textbooks, and imaging tools. Since no separate light source is required, OLED screens can easily be placed into all manner of devices. Learning applications are still some years away and flexible displays are perhaps best thought of in the category of enabling technologies at this point; but once developed more fully, thin film technology will enable whole new categories of devices.

It is not difficult to picture a display set into the cover of a school notebook, for instance. This is something that could easily be done with flexible display technology as it exists today. Like the Video-in-Print display by Americhip, the display could accept recorded video material and have its battery recharged using a very slim USB connector. Displays with small, integrated chips would be single-purpose devices, such as video-enhanced business cards (prototypes are already available) or perhaps flash cards. Flexible displays could also be attached to larger devices

with additional capabilities and more sophisticated technology, where they might function as touch screens that accept input as well as displaying output.

This technology is too new as yet to have many concrete examples of how it is being used in education, but one can envision many applications for flexible displays. A sampling of potential applications might include the following projected uses:

- **Robotics.** Prototype flexible displays have shown that the technology can be printed onto materials that are both bendable and stretchable, enabling them to be used on surfaces with complex contours, or surfaces that flex. Conformable displays could be molded on robotic parts to present information in the form of a face, for example.
- **Science.** Flexible displays will lead to increased information display opportunities. Lab equipment, for instance, might include displays with safety information or instructions for operating complex devices.
- **Textbooks.** Pharmaceutical companies are already investigating the possibilities for embedding flexible displays in medical references to illustrate methods for administering drugs. Once the cost drops sufficiently, it is conceivable that flexible displays could enhance textbooks with video or other animated content.

Flexible Displays in Practice

Because this is a very new technology, the relevant examples illustrate where this technology may take us. The following links provide examples of how flexible displays are currently being developed and used. For additional information on the current state of the technology, please see *For Further Reading*, below.

The Flexible Display Center at Arizona State University

<http://flexdisplay.asu.edu/breakthroughs/milestones>

The Milestones page lists significant accomplishments in the area of flexible displays

at the Flexible Display Center, a research and development organization at Arizona State University. The site also includes links to publications and presentations by researchers at the FDC.

OrigamiReader by NewsFlex

<http://newsflex.net>

The *OrigamiReader* is a flexible display designed to mimic the form factor and foldable nature of a standard newspaper. It draws very low power and refreshes screen content wirelessly.

Video-in-Print by Americhip

<http://www.americhip.com/>

Americhip's flexible display, called Video-in-Print, was placed in a special edition of the September 2009 issue of *Entertainment Weekly* that was sent to subscribers in New York and Los Angeles. The ad featured five video segments promoting upcoming programming on CBS.

The New York Times Envisions Version 2.0 of the Newspaper

<http://www.niemanlab.org/2009/05/the-new-york-times-envisions-version-20-of-the-newspaper/>

(Zachary M. Seward, *Neiman Journalism Lab*, 11 May 2009.) This article and accompanying video describes research and development efforts at the New York Times Co., where researchers are envisioning the next generation of newspapers — including e-ink and flexible readers.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about flexible displays.

Bend Me, Shape Me, Anyway You Want Me (PDF)

http://flexdisplay.asu.edu/files/News_Items/FDC_Economist_Jan22.pdf

(from *The Economist* print edition, 22 January 2009.) This article describes the state of flexible screen technology and reports on developments at the Arizona State University Flexible Display Center.

FDC and UDC Make Breakthrough in Flexible Display Manufacturing Process (PDF)

<http://www.universaldisplay.com/downloads/Press%20Releases/2009/FDC%20UDC%20Breakthrough%206-1-09.pdf>

(ASU Flexible Display Center and Universal Display Corporation, 1 June 2009.) This press release describes an early prototype of an OLED display manufactured directly on a flexible polyethylene naphthalate (PEN) surface.

Flexible Display Channel on YouTube

<http://www.youtube.com/flexibledisplay>

This YouTube channel highlights innovations and projects related to flexible displays, including the work done by Arizona State University's Flexible Display Center.

Programming Reality: From Transitive Materials to Organic User Interfaces (PDF)

http://ambient.media.mit.edu/assets/_pubs/coelho-programmingreality.pdf

(Marcelo Coelho *et al.*, MIT Media Lab-Fluid Interfaces Group, *CHI 2009 Workshop*, April 2009.) This paper gives a brief but thorough overview of the evolution of flexible displays and potential directions for future development.

Research Papers from the MIT Fluid Interfaces Group

<http://ambient.media.mit.edu/publications.php>

(Various Authors, MIT Fluid Interfaces Group, accessed February 24, 2010.) This is a list of current publications that provides a sense of the types of projects in which fluid interfaces could be used.

Stretchable Displays

<http://www.technologyreview.com/computing/22632/?a=f>

(Prachi Patel, MIT Technology Review, 11 May 2009.) Researchers at the University of Tokyo have developed OLED displays that can be printed onto stretchy surfaces, opening up possibilities for flexible displays that can be wrapped around a variety of shapes.

Delicious: Flexible Displays

<http://delicious.com/tag/hzk10+flexscreen>

(Tagged by K-12 Horizon Advisory Board and friends, 2010.) Follow this link to find additional resources tagged for this topic and this edition of the *Horizon Report*. To add to this list, simply tag resources with “hzk10” and “flexscreen” when you save them to *Delicious*.

METHODOLOGY

The process used to research and create the *2010 Horizon Report: K-12 Edition* is very much rooted in the methods used throughout the Horizon Project. All editions of the *Horizon Report* are produced using a carefully constructed process that is informed by both primary and secondary research. Dozens of technologies, meaningful trends, and critical challenges are examined for possible inclusion in the report for each edition. Every report draws on the considerable expertise of an internationally renowned Advisory Board that first considers a broad set of important emerging technologies, challenges, and trends, and then examines each of them in progressively more detail, reducing the set until the final listing of technologies, trends, and challenges is selected.

Much of the process takes place online, where it is captured and placed in the Horizon Project wiki. This wiki is intended to be a completely transparent window onto the work of the project, and contains the entire record of the research for each of the various editions.

The section of the wiki used for the K-12 Edition can be found at <http://k12.wiki.nmc.org>.

The procedure for selecting the topics that will be in the report includes a modified Delphi process now refined over years of producing *Horizon Reports*, and it begins with the assembly of the Advisory Board. The board as a whole is intended to represent a wide range of backgrounds, nationalities, and interests, yet each member brings a particularly relevant expertise. To date, hundreds of internationally recognized practitioners and experts have participated in the Horizon Project Advisory Boards; in any given year, a third of Advisory Board members are new, ensuring a flow of fresh perspectives each year.

Once the Advisory Board for a particular edition is constituted, their work begins with a systematic review of the literature — press clippings, reports, essays, and other materials — that pertains to emerging technology. Advisory Board members

are provided with an extensive set of background materials when the project begins, and are then asked to comment on them, identify those that seem especially worthwhile, and add to the set. The group discusses existing applications of emerging technology and brainstorms new ones. A key criterion for the inclusion of a topic is the potential relevance of the topic to teaching, learning, research, or creative expression. A carefully selected set of RSS feeds from dozens of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants throughout the process.

Following the review of the literature, the K-12 Advisory Board engaged in the central focus of the research — the research questions that are at the core of the Horizon Project. These questions were designed to elicit a comprehensive listing of interesting technologies, challenges, and trends from the Advisory Board:

- 1 *Which of the key technologies catalogued in the Horizon Project Listing will be most important to teaching, learning, or creative expression in K-12 education within the next five years?*
- 2 *What key technologies are missing from our list? Consider these related questions:*
 - a. *What would you list among the established technologies that some educational institutions are using today that arguably ALL institutions should be using broadly to support or enhance teaching, learning, or creative inquiry?*
 - b. *What technologies that have a solid user base in consumer, entertainment, or other industries should educational institutions be actively looking for ways to apply?*
 - c. *What are the key emerging technologies you see developing to the point that learning-focused institutions should begin to take notice during the next four to five years?*

- 3 *What do you see as the key challenges related to teaching, learning, or creative expression that educational institutions will face during the next five years?*
- 4 *What trends do you expect to have a significant impact on the ways in which educational institutions approach our core missions of teaching, research, and service?*

One of the Advisory Board's most important tasks is to answer these questions as systematically and broadly as possible, so as to ensure that the range of relevant topics is considered. Once this work is done, a process that moves quickly over just a few days, the Advisory Board moves to a unique consensus-building process based on an iterative Delphi-based methodology.

In the first step of this approach, the responses to the research questions are systematically ranked and placed into adoption horizons by each Advisory Board member using a multi-vote system that allows members to weight their selections. Each member is asked to also identify the timeframe during which they feel the technology would enter mainstream use — defined for the purpose of the project as about 20% of institutions adopting it within the period discussed. (This figure is based on the research of Geoffrey A. Moore and refers to the critical mass of adoptions needed for a technology to have a chance

of entering broad use.) These rankings are compiled into a collective set of responses, and inevitably, the ones around which there is the most agreement are quickly apparent.

From the comprehensive list of technologies originally considered for any report, the twelve that emerge at the top of the initial ranking process — four per adoption horizon — are further researched and expanded. Once this “short list” is identified, the group, working with both NMC staff and practitioners in the field, begins to explore the ways in which these twelve important technologies might be used for teaching, learning, research, and/or creative expression. A significant amount of time is spent researching real and potential applications for each of the areas that would be of interest to practitioners.

For every edition, when that work is done, each of these twelve “short list” items is written up in the format of the *Horizon Report*. With the benefit of the full picture of how the topic will look in the report, the “short list” is then ranked yet again, this time in reverse. The six technologies and applications that emerge are those detailed in the *Horizon Report*.

For additional detail on the project methodology or to review the actual instrumentation, the ranking, and the interim products behind the report, please visit <http://k12.wiki.nmc.org>.

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